510-4PDS/1097

REVIEW

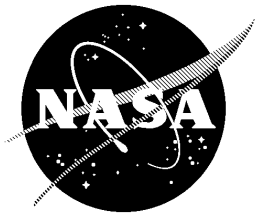
MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

Earth Science Data and Information System (ESDIS)

Level 1 Product Generation System (LPGS)

Preliminary Design Specification (PDS)

May 1997



National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

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REVIEW

Earth Science Data and Information System (ESDIS)

Level 1 Product Generation System (LPGS)

Preliminary Design Specification

Prepared by

Computer Sciences Corporation
With
Goddard Space Flight Center, Code 551

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Abstract

The Earth Science Data Information System (ESDIS) Level 1 Product Generation System (LPGS) will be operated within the Earth Observing System (EOS) Ground System (EGS) to provide Landsat 7 Enhanced Thematic Mapper Plus (ETM+) systematically corrected digital images for distribution to the Earth Observing System (EOS) Data and Information System (EOSDIS) Core System (ECS) customers. The software preliminary design presented in this document is based on the requirements contained in the LPGS functional and performance requirements specification (F&PRS), the LPGS operations concept document, and the LPGS system design specification (SDS).

Keywords: *EGS, ESDIS, Landsat 7, Level 1 Product Generation System (LPGS)*

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Section 1. Introduction

1.1 Purpose and Scope

This document establishes the preliminary software design for the Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS). The LPGS preliminary design is based on an analysis of the requirements contained in the LPGS functional and performance requirements specification (F&PRS), the LPGS operations concept, and the LPGS system design specification (SDS).

1.2 Goals and Objectives

The goals for the LPGS preliminary design are as follows:

- Provide Level 1R (L1R) and Level 1G (L1G) processing in support of the Earth Observing System (EOS) Ground System (EGS)
- Maintain system and operations cost and development schedule objectives
- Reduce risks
- Employ Level 1 (L1) processing algorithms common to both the Image Assessment System (IAS) and the LPGS
- Maximize throughput and provide flexibility for expansion

1.3 System Description

A baselined overview of the LPGS system description can be found in the LPGS operations concept (Applicable Document 2).

1.4 Definitions

The following terms, as defined in this section, are commonly used throughout this document to describe the LPGS operations concept:

- *Level 0R (L0R) digital image*—Reformatted, unrectified subinterval
- *Level 0R (L0R) product*—Level 0R products distributed by the EOS Data and Information (EOSDIS) Core System (ECS), to include all bands; 0R image data, metadata, internal calibrator (IC) data, calibration parameter file (CPF), the browse image, the payload correction data (PCD), and the mirror scan correction data (MSCD)
- *Level 1R (L1R) digital image*—Radiometrically corrected, but not geometrically resampled

- *Level 1R (L1R) product*—L1 product distributed by the ECS to customers; includes, for all requested bands, (1) user-requested files 0R image data, metadata, IC data, CPF, PCD, and/or MSCD, and (2) LPGS-generated Level 1R image data, processing quality information, and L1 metadata
- *Level 1G (L1G) digital image*—Radiometrically corrected and resampled for geometric correction and registration to geographic map projections
- *Level 1G (L1G) product*—L1 product distributed by the ECS to customers; includes, for all requested bands, (1) user-requested files 0R image data, metadata, internal calibrator data, CPF, PCD, and/or MSCD, and (2) LPGS-generated L1G image data, processing quality information, and L1 metadata
- *Production quality assessment (QA)*—Ancillary information collected and generated during L1 processing; provides information on the certainty with which corrections were made to images; nominally appended as a file to the L1 product
- *Interval*—The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) instrument
- *Subinterval*—Segment of time corresponding to a portion of an observation within a single Landsat 7 contact period
- *Worldwide Reference System (WRS) scene*—Digital image that covers an area equivalent to one of the 57,784 scene-centers (233 paths x 248 rows areas) defined by the WRS structure

1.5 Documentation

The documents listed in the subsections that follow contain details about the LPGS and external systems.

1.5.1 Applicable Documents

The following documents were used in developing the LPGS system design:

1. National Aeronautics and Space Administration (NASA)/Goddard Space Flight Center (GSFC)/Mission Operations and Data Systems Directorate (MO&DSD), 510-FPD/0196, *Earth Science Data and Information System (ESDIS) Landsat 7 Level 1 Product Generation System (LPGS) Functional and Performance Requirements Specification,* February 1997
2. —, 510-3OCD/0296, *ESDIS Level 1 Product Generation System (LPGS) Operations Concept*, February 1997
3. NASA/GSFC, *Earth Science Data and Information System (ESDIS) Mission-Specific Requirements for the Landsat 7 Mission L1 Processing*, Draft, January 1997
4. —, *Landsat 7 L1 Product Generation System (LPGS) Project Management Plan*, Draft, May 1996

5. —, *IAS System Design Specification,* December 1996

6. —, *Interface Control Document Between the Level 1 Product Generation System and the Image Analysis System (IAS),* Draft, January 1997

7. —, *Interface Control Document Between the Level 1 Product Generation System and the EOSDIS Core System (ECS),* Draft, April 1997

8. —, 560-SDS/0194, *Landsat 7 Processing System (LPS) System Design Specification,* May 1995

9. —,510-4SDS/0196, *ESDIS Level 1 Product Generation System (LPGS) System Design Specification (SDS),* March 1997

10. —, *IAS Preliminary System Design,* December 1996

11. —, *IAS Critical Design Specification,* April 1997

12. EROS Data Center, *Landsat 7 IAS Geometric Processing Subsystem Detailed Design Specification,* March 1997

1.5.2 Reference Documents

The following documents contain additional details about the LPGS, ESDIS and Landsat 7 systems and projects, and external systems:

1. NASA/GSFC, 560-3OCD/0194, *Landsat 7 Processing System (LPS) Operations Concept, Revision 2,* April 1996

2. —, *Landsat 7 Detailed Mission Requirements,* May 1995

3. —, *IAS Operations Concept,* December 1994

4. —, 430-15-01-001-0, *Landsat 7 Image Assessment System (IAS) Element Specification,* Baseline, October 1996

5. —, 514-1ICD/0195, *ICD Between IAS and LPS,* January 1996

6. —, 209-CD-013-003, *Interface Control Document (ICD) Between ECS and the Landsat 7 System,* August 1996

7. —, *Interface Requirements Document (IRD) Between ECS and the Landsat 7 System*

8. —, 505-41-18, *IRD Between EOSDIS and MITI ASTER GDS Project,* July 1995

9. —, 505-41-13, *IRD Between EOSDIS and the Landsat 7 System,* July 1995

10. EOSDIS Core System Project, 223-CD-001-002, *ECS External Data Traffic Requirements,* August 1996

11. —, 604-CD-002-003, *ECS Operations Concept for the ECS Project: Part 2B - ECS Release B,* March 1996

12. —, 305-CD-027-002, *Release-B SDPS Data Processing Subsystem Design Specification,* March 1996

13. —, 604-CD-003-002, *ECS Operations Concept for the ECS Project Part 2A - ECS Release A,* November 1995

14. —, 305-CD-029-002, *Release B CSMS System Management Subsystem Design Specification for the ECS Project,* July 1994

15. —, 194-207-SE1-001, *System Design Specification for the ECS Project,* June 1994

16. —, 305-CD-024-002, *Release B SDPS Data Server Subsystem Design Specification for the ECS Project*

17. NASA/GSFC, *Landsat 7 System and Operations Concept,* October 1994

18. NASA/GSFC/MO&DSD, *Mission Operations Concept for the Landsat 7 Ground System,* Draft, June 1995.

19. United States Geological Survey (USGS)/National Oceanic and Atmospheric Administration (NOAA), *Index to Landsat Worldwide Reference System (WRS) Landsats 1, 2, 3, and 4,* 1982

20. Computer Sciences Corporation, *SEAS System Development Methodology, Version 3,* July 1996

Section 2. Preliminary Design Overview

This section provides an overview of the LPGS preliminary design. It discusses the design methodology, system overview, and design considerations. This section also describes the open issues that have potential impact on the LPGS critical design.

2.1 Design Methodology

This section provides a brief description of the methods used to perform the preliminary design of the LPGS, including the design process and products.

2.1.1 Design Process

The LPGS preliminary design was developed using the SEAS System Development Methodology (Reference Document 20) tailored to meet the requirements of the LPGS project environment. The LPGS design has been accomplished through the following major activities:

- Development of an LPGS top-level architecture that is based on LPGS structured design and conforms to the selected hardware configuration and constraints.
- Design of the LPGS database, which is based on the refinement of a logical model of the LPGS data.
- Design of a user interface for the LPGS, based on software requirements and operations concepts.
- Design of the LPGS subsystems using a computer-aided software engineering (CASE) tool, Cadre/Teamwork, which supports the structured design methodology.
- Identification of LPGS issues that, when resolved, may impact the LPGS critical design.

2.1.2 Design Products

Several products are produced as a result of the preliminary design phase of the LPGS. They include the following:

- A model of the LPGS design in the Cadre/Teamwork CASE tool that describes the software design. (For the preliminary design, the structure charts are limited to the main module and its subordinate modules.) This model includes the following:
  - Context diagrams for each subsystem and decomposed data flow diagrams (DFDs).
  - Process specifications (P-Specs) that describe each process within a DFD.

  - Structure charts that are graphical representations of the hierarchy of the LPGS modules. Structure charts consist of modules, data, and control couples passed between modules.
  - Module specifications (M-Specs) that describe the function a module is to perform and how it performs it.
  - A data dictionary that provides definitions for data items in the LPGS software design.
- This preliminary design specification.

2.1.3 Design Conventions

The LPGS design is expressed in a notation adapted from E. Yourdon and L. Constantine and supported by the CADRE/Teamwork CASE tool. The notation is illustrated in Figure 2–1. The notation is consistent with SSDM Standard 4205 but includes the following enhancements and exceptions:

- Unit representations on structure charts include only a title; they do not include a purpose statement. The conditional execution symbol is used for transaction centers as well.
- Signals (UNIX software interrupts) are represented by asynchronous invocation from an off-sheet connector without source.
- Special notations are used for LPGS Global functions, data units, and database access routines as illustrated in Figure 2–1, part 2.

2.2 LPGS General Overview

The LPGS receives L1 product generation requests and distributes generated products to customers through the ECS at the Earth Resources Observation System (EROS) Data Center (EDC) on a first-ordered, first-processed basis.

The LPGS is the responsibility of the ESDIS Project and is to be installed at the EDC Distributed Active Archive Center (DAAC) to provide product generation and distribution support for a Landsat 7 minimum mission life of 5 years.

The LPGS produces L1 data products in electronic format corresponding to a WRS scene or partial ETM+ subintervals based on customer requests. The LPGS can produce a daily volume of 25 WRS scenes of L1R, radiometrically corrected and L1G, digitally resampled for geometric correction and geographic registration. LPGS can create digital images projected to different coordinate reference systems for any subset of the eight spectral channels collected by the ETM+ instrument or in different output formats according to other options specified in the customer's request.

The LPGS requests L0R data from the ECS and applies appended CPF, PCD, and MSCD files in producing L1 data products. The digital image created by the LPGS is provided, along with metadata and processing status and quality information, to the ECS. The ECS distributes

the entire L1 product, including the CPF, PCD, and MSCD, where applicable, to the customer.

The LPGS interfaces with the ECS within the EDC DAAC, and, also, directly with the Data Handling Facility (DHF) at EDC and with the IAS, which is contained within the DHF. [Consult the appropriate system interface control document (ICD) for more information concerning a specific interface.]

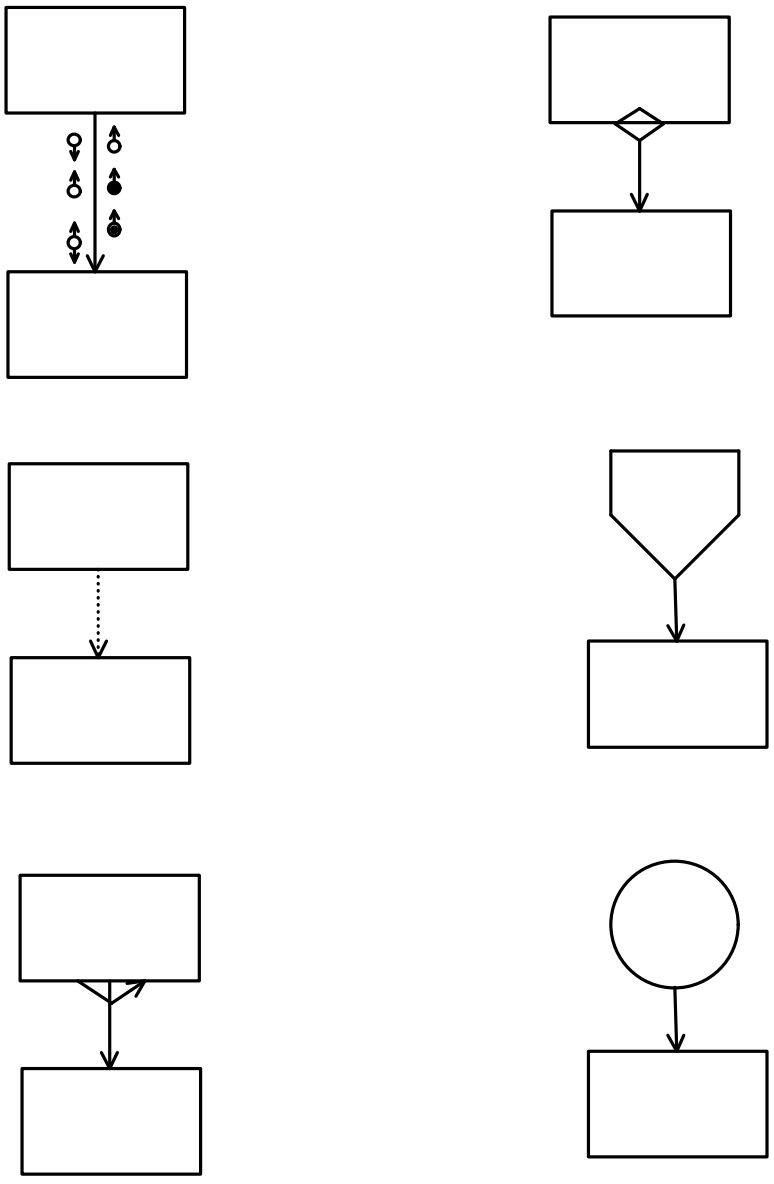

Figure 2–1. LPGS Design Conventions (1 of 2)

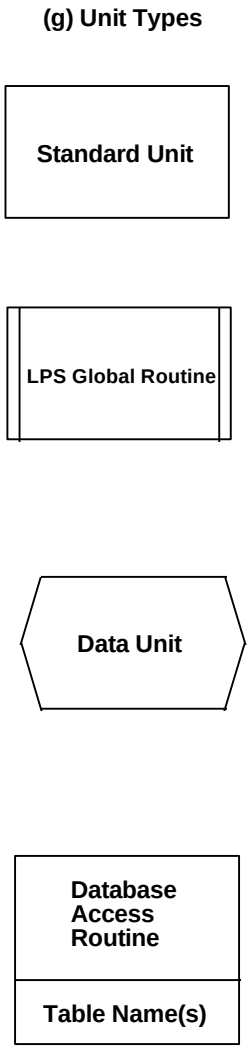

Figure 2–1. LPGS Design Conventions (2 of 2)

2.2.1 Hardware

The LPGS hardware will be located within the DAAC at the EDC in Sioux Falls, South Dakota. Figure 2–2 presents the LPGS architecture.

2.2.1.1 LPGS System Hardware

The LPGS operations system performs Level 1 processing, provides storage for the production control database, and provides temporary storage for ingesting incoming L0R products and outgoing L1 products. A backup system can be used, after proper configuration, as a production system in case the prime system fails. The operations system consists of one Silicon Graphics, Inc. (SGI) Origin 2000 server, one set of redundant array of inexpensive devices (RAID) disk arrays, two SGI O2 workstations, one X Terminal, one 8-mm tape drive, and a network printer. Additional hardware will include an Origin 2000 server, SGI O2 workstation, and an X Terminal to be used for software maintenance and testing, and as a backup in case a failure occurs in the operations support system.

2.2.1.1.1 SGI Origin Server

The SGI Origin Servers are multiprocessor systems designed for distributed computing environments. Their parallel architecture is based on a 1.2-GB-per-second system bus and can support up to 16 GB of random access memory (RAM). It is a modular building block of processors, input/output (I/O), memory, system bandwidth, power supplies, and chassis. A single deskside system module supports 1 to 8 MIPS R10000s that can be rack mounted and expanded to 128 processors. The LPGS operations server will initially have four processors with 5.6 GB of RAM. Among the items included with the standard subsystem are an Ethernet controller, Versa Module European (VME/64) controller, multiple small computer system interface (SCSI) controller, and parallel and serial ports. The operations server consists of a compact disc read-only memory (CD-ROM) drive, a 9.2-GB system disk, and an 8-mm tape drive. The second system, which is normally used for testing, is identical to the operations server except it has an additional 16 GB of system disk space for storing images.

LPGS requires a multiprocessor solution to satisfy its computational requirements, which are beyond the current capacity of a single processor.

2.2.1.1.2 SGI O2 Workstation Hardware

The SGI O2 workstations are based on the MIPS R10000 processor. These workstations are used by the LPGS analyst to perform QA and anomaly analysis (AA).

The QA workstation is connected to the Origin 2000 server on the console port and the AA workstation is connected to the LPGS server via the fiber-optic data distribution interface (FDDI) local area network (LAN). The display resolution will be 1280 x 1024. These workstations will have two 4 GB disks and TBD MB of RAM.

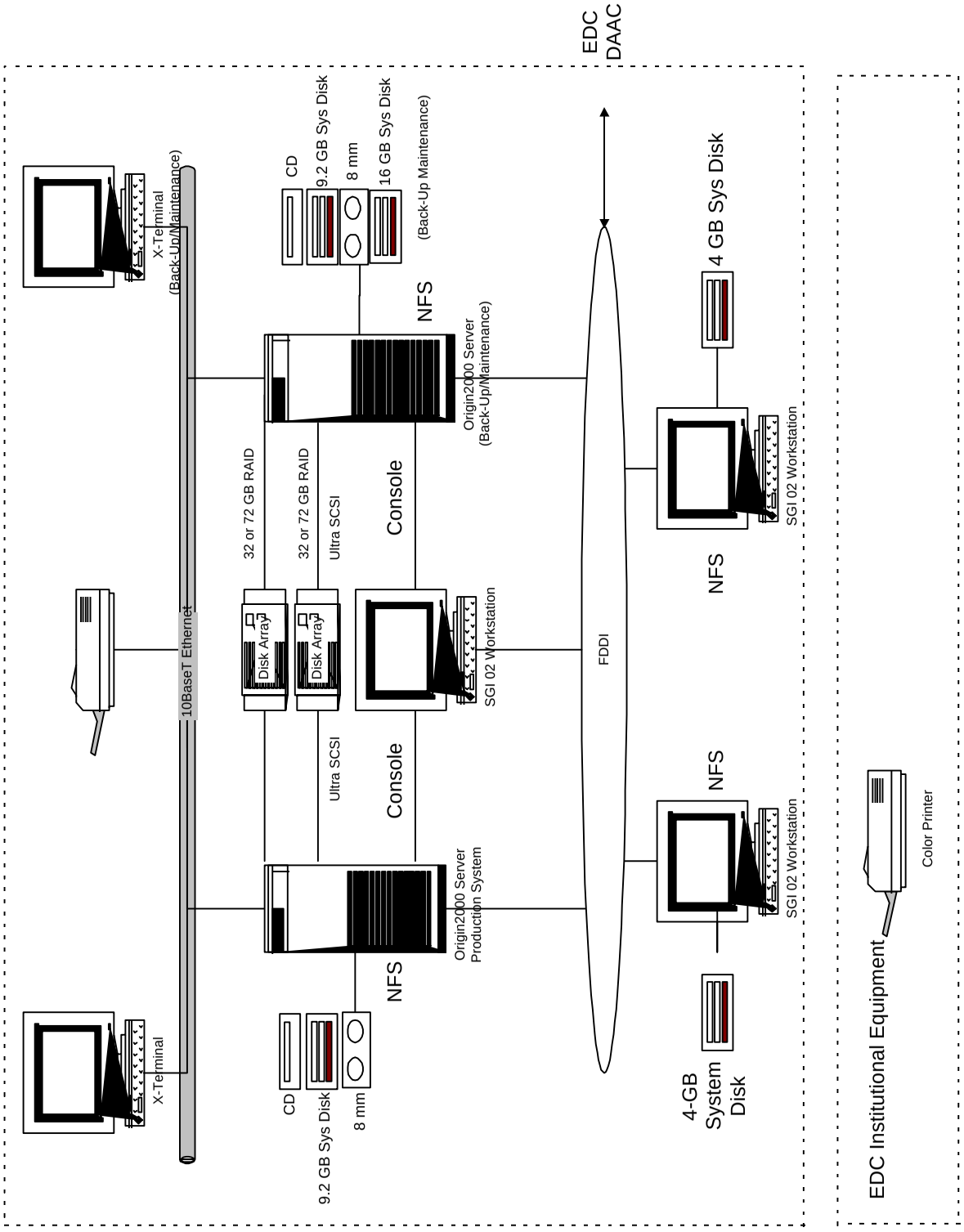

Figure 2–2. LPGS Hardware Architecture

2.2.1.1.3 X Terminals

This hardware configuration consists of two X Terminals. These terminals are used by the LPGS operators to monitor and control processing on the operations/test systems. The terminals are connected to the Origin 2000 server via the Ethernet LAN.

2.2.1.1.4 FDDI LAN

The FDDI LAN will connect the operations, development /test systems with the EDC DAAC. The LAN is rated at 100 Mbps.

2.2.1.1.5 SCSI Controller

The SCSI 2 controller is used to connect to the CD-ROM, system disk, and 8-mm tape drive. Multiple Ultra-SCSI controllers are used to connect to the RAID array to get better disk I/O performance.

2.2.1.1.6 RAID Array

Ciprico 6900 series of disk arrays supports Ultra-SCSI interface at 40 MBps. It has capacity of up to 72 GB per array. Two disk arrays giving a total of 144 GB of storage were selected for storing images and associated data.

2.2.2 Software

The LPGS context diagram is shown in Figure 2–3. The LPGS Level 0 DFD (see Figure 2–4) shows the interactions between the major subsystems of the LPGS and external interfaces.

The scope and the allocation of requirements for each subsystem was driven by the LPGS requirements. These requirements have been further divided between operations, hardware, and software and analyzed to form this preliminary design document.

The LPGS is composed of six major subsystems. They are the Data Management Subsystem (DMS), Process Control Subsystem (PCS), Radiometric Processing Subsystem (RPS), Geometric Processing Subsystem (GPS), Quality Assessment Subsystem (QAS), and the Anomaly Analysis Subsystem (AAS). Only the DMS maintains the external interface.

The following paragraphs describe the purpose and function of each LPGS subsystem. Complete preliminary designs for each subsystem are presented in subsequent sections.

- Data Management Subsystem (DMS)—The DMS maintains and provides access to LPGS data stores. The DMS handles communication protocols with LPGS external interfaces and ingests and formats files for use by other LPGS subsystems, providing cursory quality checks where needed. The DMS provides formatting and packaging of L1 output and makes these data available to external systems. The DMS also maintains LPGS disk space, populating temporary storage with data from ingested files.

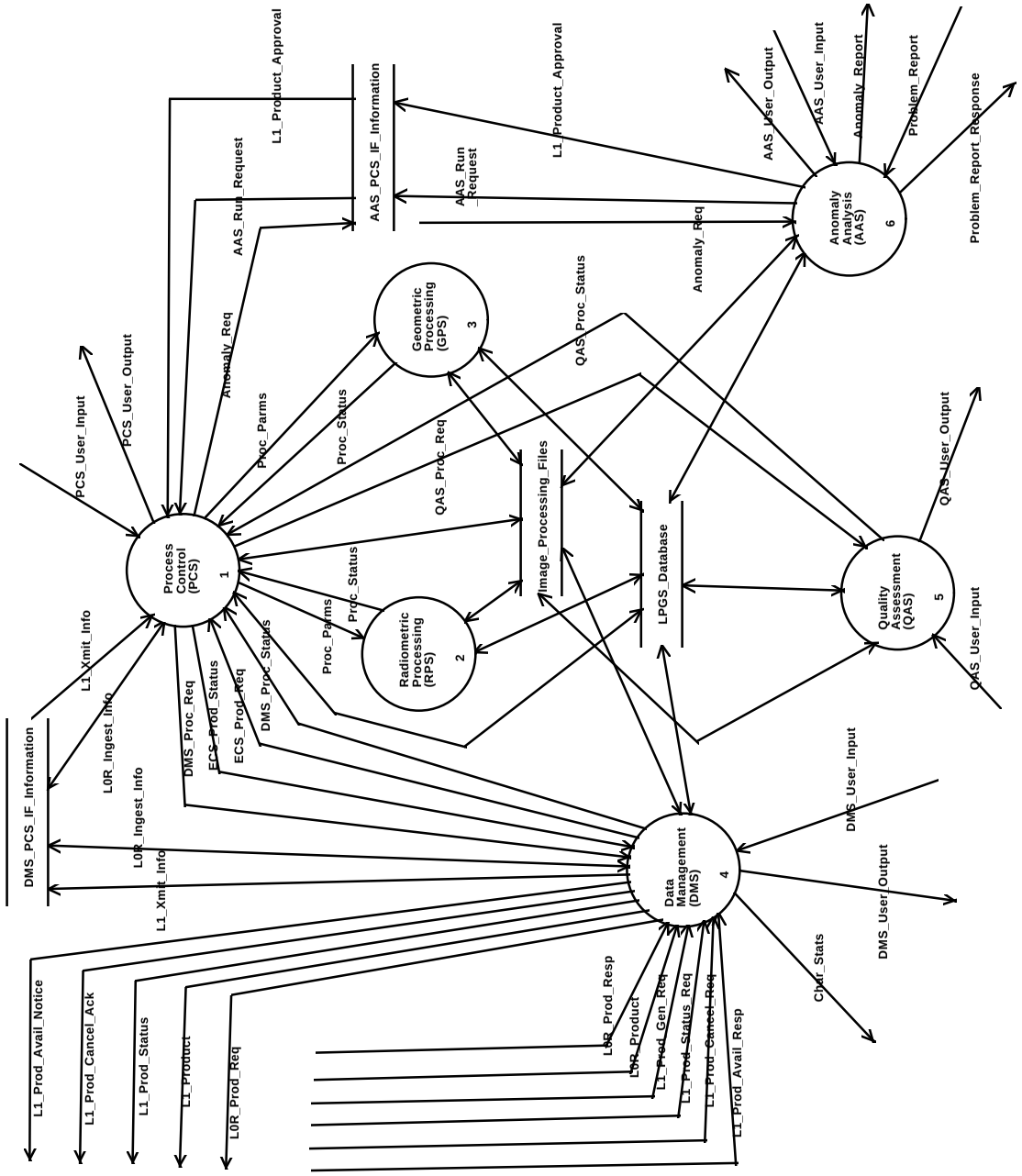

Figure 2–3. LPGS Context Diagram

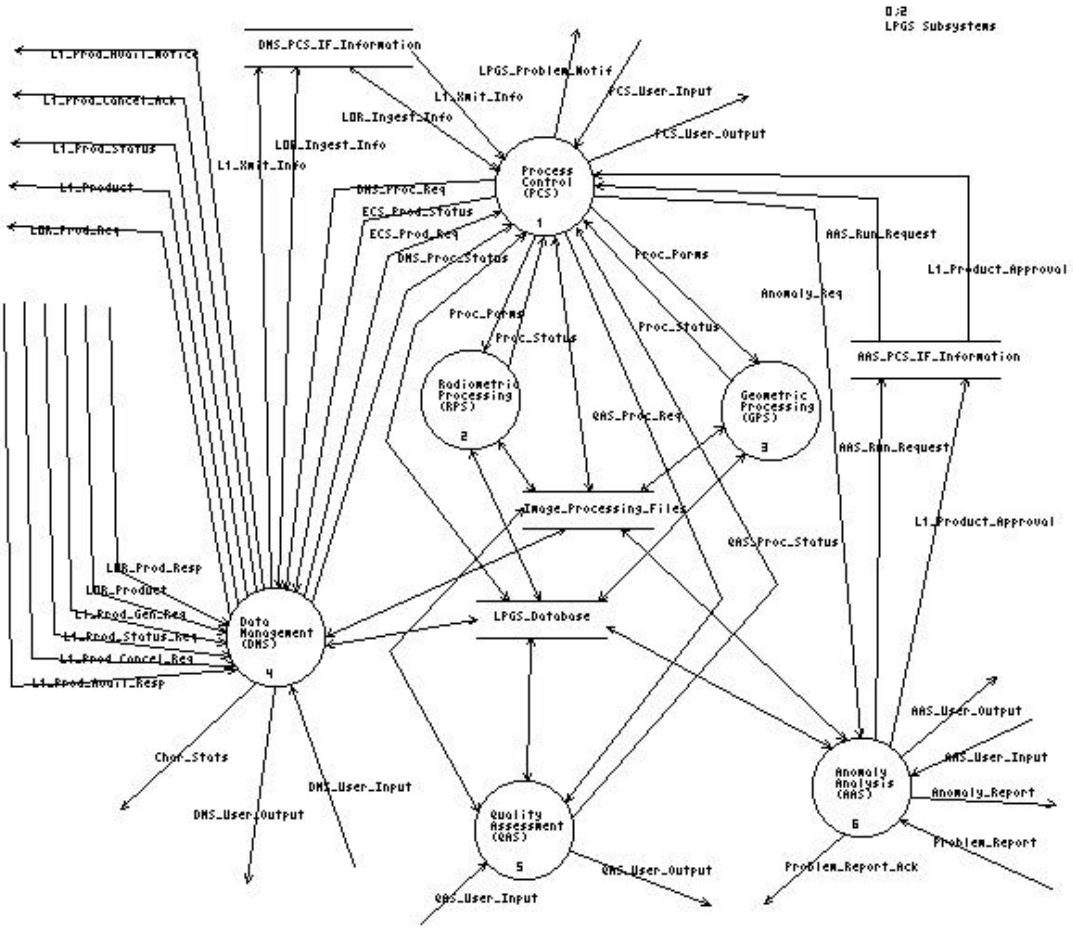
0;2
LPGS Subsystems
DMS_PCS_IF_Information
L1_Prod_Avail_Notice
L1_Prod_Cancel_Ack
L1_Prod_Status
L1_Product
LDR_Prod_Req
L1_Xmit_Info
LDR_Ingest_Info
LPGS_Problem_Notif
L1_Xmit_Info
LDR_Ingest_Info
PCS_User_Input
PCS_User_Output
Process Control (PCS) 1
DMS_Proc_Req
ECS_Prod_Status
ECS_Prod_Req
DMS_Proc_Status
AAS_Run_Request
L1_Product_Approval
Anomaly_Req
Proc_Forms
Proc_Status
Proc_Forms
Proc_Status
AAS_PCS_IF_Information
Radiometric Processing (RPS) 2
Geometric Processing (GPS) 3
QAS_Proc_Req
AAS_Run_Request
Image_Processing_Files
L1_Product_Approval
QAS_Proc_Status
LDR_Prod_Resp
LDR_Product
L1_Prod_Gen_Req
L1_Prod_Status_Req
L1_Prod_Cancel_Req
L1_Prod_Avail_Resp
Data Management (DMS) 4
LPGS_Database
AAS_User_Output
AAS_User_Input
Anomaly_Report
Problem_Report
Problem_Report_Ack
Anomaly Analysis (AAS) 6
Char_Stats
DMS_User_Input
DMS_User_Output
Quality Assessment (QAS) 5
QAS_User_Output
QAS_User_Input

Figure 2–4. LPGS Level 0 DFD

- Process Control Subsystem (PCS)—The PCS controls LPGS production planning and processing. The PCS receives product generation requests and sets up, monitors the status of, and controls processing of LPGS work orders. The PCS manages and monitors LPGS resources and provides processing status in response to customer and operator requests.
- Radiometric Processing Subsystem (RPS)—The RPS converts the brightness of the L0R image pixels to absolute radiance in response to user requests and in preparation for geometric correction. The RPS performs radiometric characterization of L0R images by locating radiometric artifacts in images. The RPS provides results of characterizations performed and processing status for use by external elements and other LPGS subsystems. The RPS corrects for the radiometric artifacts found using applicable algorithms, then converts the image to absolute radiance using internal calibrator data.
- Geometric Processing Subsystem (GPS)—The GPS creates systematically corrected L1G imagery from L1R products. The GPS provides results of characterizations performed and processing status for use by external elements and other LPGS subsystems. The GPS prepares a resampling grid, re-creates the L1R image within the grid and applies one of three optional resampling techniques. The GPS performs sophisticated satellite geometric correction to create the image according to the user-specified map projection and orientation.
- Quality Assessment Subsystem (QAS)—The QAS generates and assembles postproduction information about image artifacts and effects that were not corrected, and it produces a summary of the processed image quality. The QAS performs QA after radiometric and geometric correction of images has been made. The QAS provides tools for analyzing images, automatically and manually, through visual inspection.
- Anomaly Analysis Subsystem (AAS)—The AAS analyzes L1 images and associated postproduction information about image artifacts and effects to resolve image production anomalies. The AAS provides results of such problem analysis to the DHF for further investigation.

2.2.3 External Interface

As shown in Figure 2-3, the LPGS has external interfaces with the ECS, IAS, and DHF.

2.2.3.1 Interface to ECS

The primary LPGS interface is with the ECS within the EDC DAAC. The LPGS receives L1 product generation requests from the ECS. L1 product generation requests are processed by the LPGS, which submits a L0R product request to the ECS. The LPGS then electronically retrieves L0R products, including calibration parameter files, in response to the request. During L1 data generation, the LPGS generates production status information. Production status may be distributed to the ECS in response to production status requests transmitted to

the ECS by customers. After completion of L1 processing, the images and other pieces of the L1 product are electronically provided to the ECS. The ECS may transmit an L1 product generation cancellation request to terminate processing of previously transmitted product generation requests.

2.2.3.2 Interface to IAS

During L1 image processing, various characterizations for effects from saturated detectors, coherent noise, and memory effects are performed. The LPGS collects results of the characterizations and periodically distributes them to the IAS for trending and further analysis.

2.2.3.3 Interface to DHF

The LPGS maintains an interface to the DHF for forwarding anomaly reports. Some anomalies identified in LPGS postproduction analysis cannot be attributed to the L1 production generation request, processed L0R image, or the L1 production process, and they cannot be resolved by LPGS production analysts. The available information about these anomalies is forwarded to the DHF in the form of an anomaly report.

2.3 Design Considerations

This subsection presents the concepts and philosophy that drive the LPGS design.

2.3.2 Global Library Areas

A library of general purpose functions was defined during preliminary design. During detailed design, the scope of the library will be expanded and functionality refined.

2.3.3 Database Interface

A trade-off study (performed by the IAS project) resulted in the decision to place all database access through embedded Structured Query Language (SQL) in separate Database Access Routines (DBARs) that contain little more than the SQL statements themselves. The rationale for doing so is that these smaller units run less risk of encountering compile-time problems with the Oracle embedded SQL preprocessor.

2.3.4 Error Handling Philosophy

The LPGS error handling philosophy distinguishes a number of classes of errors. A primary distinction is made between correctable and uncorrectable errors. The LPGS philosophy for correctable errors is to report and handle the error in the unit that detects it. Fatal errors cause a process to terminate abnormally and immediately. No opportunity for recovery exists at the time of the error's occurrence. Catastrophic hardware failures or receipt of a UNIX SIGKILL signal can cause a process to terminate abnormally. Nonfatal, uncorrectable errors are those that make further processing impossible but do not abort the process. The process is able to respond to the error at the time of its occurrence. For fatal errors, the LPGS error handling

philosophy provides for error detection by a monitor process. In general, each process that performs a function is invoked and monitored by a controlling process. A fatal error in the functioning process is detected by the monitoring process. In most cases, correction after fatal errors is unnecessary; the LPGS's state remains unchanged until a process terminates successfully. The LPGS design treats most errors as uncorrectable and terminates execution gracefully when an error occurs. This decision is intended to minimize development costs without impact to system requirements. The decision is feasible because, operations on the LPGS are repeatable. An uncorrectable error that terminates execution is therefore corrected by repeating the operation that terminated.

Robust error reporting is central to the LPGS error handling philosophy for all types of errors. Robust error reporting consists of detailed error and status messages delivered throughout processing. LPGS error reporting uses the IRIX operating system's system log services to record all status and error message from the LPGS. Each error and status message is time-tagged and assigned a severity value by the unit that generates the error. To aid in troubleshooting, each message also contains the name of the unit that generates the error and the source code line number of the error report function call. The LPGS design reports each detected error by the unit that first encounters the error. The LPGS design allows the operator to specify a severity level cut-off that the LPGS will use to filter the messages displayed. Only messages with the specified, or higher, severity will be displayed.

2.3.5 File Maintenance

The LPGS design outputs the following types of files:

- Level 1R and Level 1G output files.
- Temporary files created by various LPGS software components and deleted at program termination and analyst's completion of assessment.

2.4 Open Issues

TBD

Section 3. LPGS Operational Scenarios

3.1 Introduction

Operational scenarios describe the allocation and flow of LPGS operations activities between the operations staff and subsystems. The allocation of LPGS requirements to subsystems, hardware, and operations are found in Appendix A. Although the majority of nominal LPGS functions such as product ingest, formatting and distribution, radiometric and geometric correction, and initial quality assessments are intended to be performed in an automated manner, without operator intervention, operations staff have roles in both nominal and non-nominal activities. The scenarios are considered preliminary and are meant to provide the basis for dialogue between systems engineering, development, and operations representatives that will help identify details that will be incorporated into scenarios defined in the LPGS Critical Design Specification (CDS). Key operations activities have been categorized as nominal and non-nominal as indicated below.

Nominal Activities	Non-nominal Activities
1. Start up LPGS	1. Analyze problem report
2. Shut down LPGS	2. Process L1 product (non-nominal)
3. Process L1 product (nominal end-to-end L1 processing flow)	3. Recover from LPGS failure
4. Cancel L1 processing	4. Respond to ECS communications link failure
5. Transfer characterization results to IAS	5. Generate statistics

The flow of operations activities performed by operations staff and LPGS subsystems to accomplish key LPGS functions are detailed in the sections that follow.

3.2 Operations Staff

Operations staff are required to perform activities that the LPGS subsystems can not perform automatically. Operations activities performed by the operations staff can be grouped into system operations, production control, quality assessment, and anomaly analysis categories. System operations, performed by the system operator (Sys Opr), include initiating system startup and shutdown, configuring system software and hardware, backing up system software in support of both nominal and contingency operations, and monitoring system status. Production control operations, performed by the production operator (Prod Opr), include managing L1 processing queues, manually modifying LPGS work orders (WOs), initiating statistics generation, and transferring characterization results. Quality assessment (QA) and anomaly analysis (AA) activities are performed by the analyst. The analyst visually inspects images before distribution, analyzes and inspects processing quality information, and resolves processing anomalies found both before and after distribution of the L1 product. A single operations staff member can support multiple operations staff positions, and multiple staff members can support a single operations position as hardware architecture permits.

3.3 Nominal Operations

Nominal operations scenarios are presented in the sections below according to the sequentially numbered steps of the operations activities and the subsystems or operators by which they are performed. Where steps are repeated, a line with an arrow head is placed next to the series of steps that are repeated. The arrow head is placed next to the first step in the repeated series., A dotted line with an arrowhead is provided where steps may optionally be repeated. The scenarios are provided as examples of typical operations activities and are not intended to indicate the only sequence of activities that may occur during nominal activities.

3.3.1 Start Up LPGS

LPGS startup activities are performed to boot and power on LPGS hardware, initialize LPGS user interface, and initiate optional periodic monitoring activities.

Step	Subsystem/Operator	Action
1.	Sys Opr	Power on/boot workstations and monitors and log onto operations interface workstation
2.	Sys Opr	Start Oracle Database Management System (DBMS)
3.	Sys Opr	Execute LPGS initialization task to start background programs
4.	Sys Opr	Display LPGS main window
5.	Sys Opr	Display and monitor LPGS subsystem status
6.	DMS	Verify ECS availability
7.	Prod Opr	Display and monitor LPGS processing status
8.	Analyst	Log onto QA/AA workstation
9.	Analyst	Display anomaly main window
10.	Analyst	Display anomaly status table

3.3.2 Shut Down LPGS

LPGS shutdown activities are performed to take LPGS hardware off line, and terminate all software processes. The Start Up LPGS scenario must be performed prior to the Shut Down LPGS operations scenario.

Step	Subsystem/Operator	Action
1.	Sys Opr	Display LPGS main window
2.	Sys Opr	Display and monitor LPGS subsystem status
3.	Prod Opr	Display LPGS processing status and initiate LPGS termination script
4.	PCS/DMS/QAS	Terminate current WO processing
5.	Analyst	Exit anomaly windows, and log off QA/AA workstation
6.	Sys Opr	Notify ECS of termination
7.	DMS	Terminate communications with ECS
8.	Sys Opr	Exit LPGS User Interface
9.	Sys Opr	Terminate Oracle DBMS

Step	Subsystem/Operator	Action
10.	Sys Opr	Power off workstations and monitors

3.3.3 Process L1 Product (Nominal End-to-End Processing Flow)

The L1 product processing scenario provides an example of nominal processing of a single L1G product without errors, human intervention, or visual inspection of the product before distribution. The system startup scenario must be performed before commencement of the process L1 product scenario. The following scenario assumes that the produced L1 image is of acceptable quality and that WOs have, by default, been set to indicate no visual inspection.

Step	Subsystem/Operator	Action
1.	DMS	Receive L1 product generation request from ECS
2.	DMS	Forward L1 product generation request to PCS
3.	PCS	Save data from L1 product generation request in LPGS database
4.	PCS	Generate WO and save in database; link WO to scripts and set up parameters with database parameters extracted from L1 product generation request
5.	PCS	Generate WO directories
6.	DMS	Assess system ingest criteria for L0R product and indicate whether ingest criteria are satisfied
7.	DMS	Identify the next WO that needs L0R data
8.	DMS	Generate an L0R product request to obtain for L0R data
9.	DMS	Send L0R product request to ECS
10.	DMS	Send and receive handshaking and protocol messages necessary to receive L0R product from ECS
11.	DMS	ECS sends the L0R product to LPGS
12.	DMS	Receive L0R product response providing notification of data availability
13.	DMS	Acknowledge receipt of L0R product response
14.	DMS	Verify against WO that correct L0R product files have been received
15.	DMS	Move L0R product files to WO input directory
16.	DMS	Catalog the L0R product files in the database
17.	PCS	Assess resource availability and start WO processing when adequate resources available
18.	PCS	Set up the L0R product processing script parameters
19.	PCS	Start L0R product processing script
20.	DMS	Check data accuracy and generate L0R statistics and consensus PCD and MSCD files
21.	DMS	Update database with results
22.	PCS	Assess L0R product processing script status and determine that processing continues
23.	PCS	Set up the L1R processing parameters

Step	Subsystem/Operator	Action
24.	PCS	Start L1R processing script
25.	RPS	Perform radiometric characterization and correction
26.	RPS	Update database with results
27.	PCS	Assess L1 processing script status and determine that processing continues
28.	PCS	Set up the QAS thresholds and parameters in L1R quality script
29.	PCS	Start L1R quality script
30.	QAS	Assess results of radiometric characterization and correction
31.	QAS	Update database with L1R quality assessment results
32.	PCS	Assess L1R quality script status to determine that processing continues
33.	PCS	Set up the L1G processing parameters
34.	PCS	Start L1G processing script
35.	GPS	Perform geometric correction
36.	GPS	Update database with results
37.	PCS	Assess L1G processing script status and determine that processing continues
38.	PCS	Set up the QAS thresholds and parameters in L1G quality script
39.	PCS	Start L1G quality script
40.	QAS	Assess results of geometric correction
41.	QAS	Update database with L1G quality assessment results
42.	PCS	Assess L1G quality script status to determine that processing continues
43.	PCS	Set up the formatting script parameters
44.	PCS	Start formatting script
45.	DMS	Format L1G product
46.	DMS	Package L1G product
47.	DMS	Move the product to the L1 output directory
48.	DMS	Check the product in L1 output directory for completeness
49.	DMS	Update database with formatting script results
50.	PCS	Assess formatting script status to determine that processing continues
51.	PCS	Provide notification to DMS when the product is ready for delivery
52.	DMS	Provide ECS notification of L1 product availability
53.	DMS	Send and receive handshaking and protocol messages necessary to provide L1 product to ECS
54.	DMS	ECS retrieves L1 product from LPGS
55.	DMS	Receive L1 product availability response
56.	DMS	Acknowledge receipt of L1 product availability response
57.	DMS	Update LPGS database to indicate that the L1 product has been delivered and the product request is complete

Step	Subsystem/Operator	Action
58.	DMS	Mark the files associated with WO for deletion

3.3.4 Cancel L1 Processing

LPGS activities for canceling L1 processing are performed to terminate WO processing and resolve all data associated with the canceled request. Requests for canceling L1 processing can be received at any time after LPGS receives the applicable L1 product generation request. Therefore, an L1 production cancellation request can be received prior to initiation of any processing, or even after all associated processing has been completed and the L1 product has been distributed to the ECS. The L1 product cancellation acknowledgment will indicate the disposition of the cancellation and whether processing was successfully canceled or that the product had already been distributed to ECS. The following scenario assumes that L1 processing of the applicable WO has been conducted up to Step 37 of the Process L1 Product scenario in Section 3.3.3, which assesses the status of L1G processing script results.

Step	Subsystem/Operator	Action
1.	DMS	Receive L1 product cancellation request from ECS
2.	DMS	Forward L1 product cancellation request to PCS
3.	PCS	Write L1 product cancellation request to LPGS database
4.	PCS	Send alert to operations interface display
5.	Sys Opr	Display cancellation request
6.	Sys Opr	Display current status of applicable WO
7.	Sys Opr	Confirm cancellation of applicable WO
8.	PCS	Update cancellation requests in LPGS database
9.	PCS	Assess status of L1G processing script for applicable WO and determine that WO processing continues, end of L1G processing script
10.	PCS	Check cancellation requests in LPGS database
11.	PCS	Do not initiate execution of L1G quality assessment script or subsequent scripts that are executed to complete nominal L1G processing
12.	PCS	Mark product request and WO for cancellation in LPGS database
13.	PCS	Mark WO directories for deletion in LPGS database
14.	PCS	Create and send to DMS L1 product cancellation acknowledgment
15.	DMS	Send L1 product cancellation acknowledgment to ECS

3.3.5 Transfer Characterization Results to IAS

LPGS activities for transferring characterization results to IAS are performed to provide IAS with a source of L0R and L1 radiometric characterization statistics for use in trending, and to enable deletion of characterization statistics that are stored in the LPGS database. Characterization results are transmitted on a basis as indicated in the LPGS/IAS ICD; however, system operators maintain the capability to initiate transmission, as required, in

response to the project and the EDC DAAC Manager. The LPGS/IAS ICD is in draft format, and the actual methods and activities required to transfer characterizations results have not been baselined. The following scenario assumes that characterization results have been written to the LPGS database for completed WOs, and that the startup system scenario has been successfully completed.

Step	Subsystem/Operator	Action
1.	Sys Opr	Display LPGS main window on operations interface workstation
2.	Sys Opr	Make selection to transfer characterization results to IAS
3.	DMS	Identify characterization results records in LPGS database that satisfy transmission criteria and have not been previously sent
4.	DMS	Export table of characterization results from Oracle database
5.	DMS	Establish interface with IAS
6.	DMS	Transfer characterization results file to IAS
7.	DMS	Confirm data transfer via ftp
8.	DMS	Mark exported characterization results in LPGS database as having been sent
9.	DMS	Mark WOs for which characterization results were transmitted in LPGS database

3.4 Non-nominal Operations

Non-nominal operations scenarios are presented in the sections below. The scenarios are provided as examples of typical non-nominal operations activities and are not intended to indicate the only sequence of activities that may occur.

3.4.1 Analyze Problem Report

LPGS anomaly analysis activities are performed to identify and resolve anomalies in images produced by the LPGS. The scenario below provides an example of anomaly analysis in which a problem report is received for an image that has been distributed to a customer, the image problems were reproduced upon reprocessing, and the cause of the problem was found and corrected.

Step	Subsystem/Operator	Action
1.	Analysts	Receive problem report from DAAC Manager
2.	Analyst/AAS	Display anomaly status table on AAS display and add problem report to anomaly status table
3.	Analyst	Select problem report for analysis
4.	Analyst	Visually examine problem report and production history files
5.	Analyst	Extract request and WO associated with problem report
6.	Analyst/AAS	Generate diagnostic WO to monitor results and place in suspend mode
7.	AAS	Generate WO directories
8.	Prod Opr/Analyst/ AAS	At an appropriate time, activate and promote the WO
9.	Analyst	Monitor and control script processing

Step	Subsystem/Operator	Action
10.	Analyst	Verify that results are consistent with original product received by the customer
11.	Analyst	Visually examine user request, WO, event log, calibration file, quality reports, etc.
12.	Analyst	Visually examine L0R image and L1R image
13.	Analyst	Find the cause of the problem which appears to be correctable, and document findings in anomaly status table
14.	Analyst/AAS	Generate new diagnostic WO with corrections and place in suspend mode
15.	AAS	Generate WO directories
16.	Prod Opr/ Analyst/ AAS	At an appropriate time, activate and promote the WO
17.	Analyst	Monitor and control script processing
18.	Analyst	Verify that results are correct and update anomaly status table
19.	AAS	Update WO status in LPGS database
20.	AAS	Save corrected results to designated location
21.	Analyst	Send problem report response about corrected results to the DAAC Manager and the DHF
22.	AAS	Add results to anomaly history

3.4.2 Process L1 Product (Non-nominal)

The non-nominal process L1 product scenario provides an example of the resolution of image anomalies found during routine L1 production processing. The scenario assumes that the nominal process L1 product scenario, in Section 3.3.3, has been conducted up to Step 32. At this point in the L1R processing, quality statistics exceed established thresholds and do not meet quality criteria. This scenario example assumes that the image problem can be resolved by modifying image processing parameters that are specified in the processing WO.

Step	Subsystem/Operator	Action
1.	QAS	L1 image fails automated quality assessment
2.	PCS	Assess L1R quality script status and add anomaly to anomaly status table
3.	Analyst	Bring up anomaly status table on AAS display and select anomaly that failed quality assessment
4.	Analyst	Visually examine event log, user request, WO, quality reports, L1 data files, calibration file, etc.
5.	Analyst	Visually examine L1R and L0R images
6.	Analyst/AAS	Generate benchmark WO to verify that LPGS is working properly; activate and promote the WO
7.	LPGS	Run benchmark
8.	Analyst	Confirm that benchmark run is successful
9.	Analyst/AAS	Generate diagnostic run WO to reprocess the user request with AAS monitoring capabilities - save WO in database and place WO in suspend mode
10.	AAS	Generate WO directories

Step	Subsystem/Operator	Action
11.	Prod Opr/ Analyst/AAS	At an appropriate time, activate and promote the WO
12.	Analyst	Monitor and control script processing
13.	Analyst	Detect cause of problem that appears correctable; verify necessary processing modifications are documented in log
14.	Analyst/AAS	Generate reprocessing WO by correcting original WO and add WO to database
15.	AAS	Generate WO directories
16.	LPGS	Process WO - this time it passes and is sent to the customer via ECS
17.	DMS	Update LPGS database
18.	PCS	Mark diagnostic WOs for deletion and update anomaly status table
19.	AAS	Display anomaly status table to show that product was successfully transferred and update anomaly history

3.4.3 Recover From LPGS Failure

LPGS failure recovery activities are performed to isolate and resolve LPGS subsystem failures, notify DAAC management and other affected elements of processing impacts, and continue product processing to the greatest extent possible when failures are isolated to a specific subsystem. The following scenario provides an example of recovery from failures within the PCS, and assumes that the failure can be resolved by system and production operators without modifying the controlled LPGS configuration. The scenario is considered preliminary and details will be updated in the LPGS CDS.

Step	Subsystem/Operator	Action
1.	PCS	WO control and scheduling processes terminate abnormally
2.	PCS	Display error alert on all configured workstations
3.	Prod Opr	Attempt process restart
4.	Sys Opr	Display LPGS system status on operations interface workstation
5.	Prod Opr	Display LPGS WO processing status
6.	Prod Opr	Estimate processing impacts
7.	Sys Opr	Notify DAAC Manager and EDC DAAC User Services of failure via voice communications, and estimate processing impacts
8.	Prod Opr	Manage processing queue to suspend initiation WO processing until process failure has been resolved
9.	Analyst	Continue quality assessments and image analysis as much as possible
10.	Sys Opr/Prod Opr	Follow operations procedures to resolve and recover from failure
11.	Sys Opr	Notify DAAC Manager and EDC DAAC User Services of estimated time to return to full operations
12.	Sys Opr/Prod Opr	Resolve failure
13.	Sys Opr	Restart PCS software

Step	Subsystem/Operator	Action
14.	Sys Opr	Display LPGS system status and confirm successful execution
15.	Prod Opr	Display LPGS WO processing status
16.	Prod Opr	Resume initiation of WOs that were suspended
17.	Sys Opr	Notify DAAC Manager and EDC DAAC User Services of return to full operations

3.4.4 Respond to ECS Communications Link Failure

This scenario describes the operations activities performed in response to a failure of the LPGS communications link to ECS. The scenario is considered preliminary and details will be updated in the LPGS CDS when the ECS/LPGS ICD, and LPGS user interface software have been baselined. The scenario assumes that the communications failure occurs during prime shift staffing.

Step	Subsystem/Operator	Action
1.	DMS	Receive unrecoverable ECS gateway error messages
2.	DMS	Display communication error alert on all configured workstations
3.	Sys Opr	Contact ECS operators via voice communications to confirm outage
4.	Sys Opr	Display LPGS system status on operations interface workstation
5.	Sys Opr	Initiate execution of script to isolate communications links failure
6.	Prod Opr	Display LPGS WO processing status
7.	Prod Opr	Manage processing queue to suspend processing of WO that have not yet been processed until communications have been reestablished.
8.	Sys Opr	Access LPGS main window and suspend transmission to ECS of notification that L1 products are available
9.	PCS/DMS/ QAS/AAS	Continue WO processing that has already been initiated until all received L0R data have been processed
10.	Sys Opr	Receive notification via voice that ECS communications failure has been resolved
11.	Sys Opr	Start communications session with ECS
12.	Sys Opr	Display LPGS system status and resume all suspended communications
13.	Prod Opr	Resume initiation of WOs that have not yet been processed
14.	DMS	Receive production status requests from ECS for WOs in queue
15.	DMS	Send production status request to PCS
16.	PCS	Receive production status request from DMS and return WO status
17.	DMS	Provide production status to ECS

3.4.5 Generate Statistics

The generate production statistics scenario details operations performed to generate metrics of LPGS L1 processing activities.

Step	Subsystem/Operator	Action
1.	Sys Opr	Display LPGS main window
2.	Sys Opr	Initiate execution of processing statistics script
3.	DMS	Extract processing records from LPGS database
4.	DMS	Format records into statistics report
5.	DMS	Display report on LPGS operations interface workstation
6.	Sys Opr	Print report

Section 4. Global Libraries

4.1 Introduction

The LPGS will use global libraries to implement communication among subsystems and functionality common to the subsystems. The global libraries will also contain non-POSIX-compliant software that needs to be isolated for future software porting purposes.

4.2 Design Overview

This section provides an overview of the global library design and a discussion of the considerations used in the design process.

4.2.1 Library Overview

As mentioned, the global libraries consist of functions that are shared by the LPGS subsystems or are non-POSIX compliant.

4.2.2 Design Considerations

The major assumptions or considerations influencing the design of the global library software are as follows:

- All global library routines will be designed so that the application programmatic interfaces (API) are kept to a minimum. On the other hand, the APIs from the global libraries to the operating system will be transparent when the global functions are implemented.
- Each global function will have its own structure chart and is invoked by the subsystems.
- A global library name will follow standard LPGS naming conventions but will be prefixed with “xxx” to identify it as a global function.
- The global functions will be responsible for releasing memory allocated within the global function.

4.3 Library Design

The LPGS global routines are categorized into three groups: User Alarm Logging, Work Order Status Logging, and Input Parameter Retrieval. A description of each group is provided in the following subsections.

4.3.1 User Alarm Logging

When an application process encounters a severe error requiring operator attention, it will call the xxx_UserAlarm function to forward the error to the user. xxx_UserAlarm will record the

error message in the Work Order log. Upon the operator's request, the user interface will display all active user alarms written to the Work Order log.

However, when an application process is run outside the LPGS Process Control Subsystem (PCS), the xxx_UserAlarm will call the xxx_Logger to record the alarm in the Work Order log.

4.3.2 Application Status Logging

Application processes will report their status to the Work Order log. The xxx_Logger function allows the application process to write a formatted message to the Work Order log. The formatted message will contain the process name, process ID, function name, function line number, time, and message. This standardized message output will facilitate the querying of the Work Order log.

4.3.3 Input Parameter Retrieval

Application processes will require input parameters to control their execution. To retrieve an input parameter's value, the application process will call xxx_GetParam with the parameter's name and the address of where to store the parameter's value(s). Upon successful completion, xxx_GetParam returns the parameter's value at the specified address.

xxx_GetParam first retrieves the parameter's value from an Object Descriptive Language (ODL) file. xxx_GetParam then converts the parameter into the correct data type and data structure (i.e., array), and finally returns it to the caller.